

## ***Scholarship of Teaching and Learning***

# **"Of Course I'm Communicating; I Lecture Every Day": Enhancing Teaching and Learning in Introductory Statistics**

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*This article focuses on one instructor's evolution from formal lecturing to interactive teaching and learning in a statistics course. Student perception data are used to demonstrate the instructor's use of communication to align the content, students, and instructor throughout the course. Results indicate that the students learned, that communication in the alignment process played a role in the learning, and that the instructor used four key categories of communication: encouraging open communication, demonstrating examples interactively, structuring opportunities for application through problem-solving, and engaging students in reflection about their learning. The article concludes with the instructor's reflections on how communication and the approach to teaching and learning changed as a result of conducting the scholarship of teaching and learning in the course.*

*Keywords: higher-education teaching methods, lecture, classroom interaction, statistics education*

On several occasions, an instructional consultant and I had talked on the telephone

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about my teaching in my introductory statistics course. The third time, the conversation unfolded as follows:

Consultant: "How's the course going?"

Instructor: "It's okay."

Consultant: "Are you getting feedback from the students about their learning?"

Instructor: "Yeah, I'm asking them questions in class."

Consultant: "But, are you communicating with them about some of the things you are trying to do in the course?"

Instructor: (I thought, what does he think? That I am *not* communicating?) "Of course, I'm communicating with them; I lecture every day."

There was a pause on the other end of the line. Then, the consultant responded:

"You know, there's a lot more to communication than simply lecturing to the students or answering their questions."

I knew this, of course, but I had not thought explicitly about my use of communication in the course. That conversation was an important beginning to a more comprehensive discussion about teaching and learning in statistics.

### Teaching and Learning in Statistics

In recent years, the discipline of statistics has moved from focusing on content and methods (Anderson & Loynes, 1987) to calling for statistical thinking as a major goal in introductory courses (Butler, 1998; Cobb, 1992, 2000; Garfield, Hogg, Schau, & Whittinghill, 2002). Furthermore, experts have stressed that instructors who want students to think in statistical ways have to lecture less and find ways to engage students actively (Cobb, 2000; delMas, Garfield, & Chance, 1999; Moore, 2000).

I had tried to make my course more interactive. However, such change was not easy for me. My view of teaching and learning was firmly grounded in the way I was taught in formal classroom settings, in the way I learn best, and in my belief that my role as instructor was to tell students what they need to know. I struggled with having to abandon the instructional approach with which I was most comfortable.

In addition, I was unclear about how to address the varied needs of my students. The challenges of motivating students in introductory statistics courses are well documented (Gal & Ginsburg, 1994; Gelman & Nolan, 2002). Some of my students were like those described by Gal and Ginsburg (1994), having trouble "due to non-cognitive factors, such as negative attitudes or beliefs towards statistics" (p. 1). Other students, as Chance (1997) described, had little interest in the material, and a few even reinforced the view that introductory statistics can be perceived by students as painful, difficult, and unpleasant (Friedman, Friedman, & Amoo, 2002; Garfield et al., 2002). A few of them were graduate students, and I certainly knew from my own experience that any of them with a propensity for "quantitative thinking" enrolled with strong expectations about how the course should be taught.

As the consultant and I discussed my students, the content, and my background,

preferences, and perspectives, I remained committed to statistical thinking as an outcome. I realized, however, that I needed better ways to assess how I was helping students achieve that goal. I was aware that, increasingly, colleagues in my discipline had advocated innovative ways of assessing learning in introductory statistics courses (Chance, 1997, 2002; Garfield, 2000; O'Connell, 2002), but I imagined that those approaches were for others at more advanced stages of professional development. Besides, there was a huge gap between knowing what *should be* done and knowing *how* I should proceed, especially given my lack of pedagogical expertise.

### Grounding for the Study

When the consultant explained that Wulff's (1985, 1988) alignment model of teaching effectiveness depicts how effective teachers align content, the students, and themselves to achieve desired learning outcomes, the pieces began to fall into place. In stressing the importance of communication, he pointed out that "teachers who want to be effective know not only how to obtain information about themselves, the content, and the students, but also how to use that information to develop communication that will make alignment possible" (Wulff, 1988, p. 30). I knew then that I wanted to focus a study on communication. I settled on the following guiding question:

RQ: How can I use communication to align the content, the students, and myself for the best possible learning in my statistics course?

### Methods

#### Overview

Working with the consultant, I conducted a study with the 15 undergraduate and graduate students from mathematics, statistics, engineering, and physics who were at that time enrolled in my introductory course. I defined *communication* broadly as transactions between the students and me and between and among the students (Cooper & Simonds, 1999). I focused on using communication to align the content, students, and myself through lectures, problem-solving activities, the use of office hours, and students' written reflections about their learning. I initiated the student reflections after the consultant and I decided that I needed an additional mechanism to engage students in thinking about their learning and to provide additional insight into their progress.

I approached the study as the scholarship of teaching and learning (Hutchings & Shulman, 1999), grounded in action research (Kemmis, 1988) and classroom research (Cross & Steadman, 1996) in which "teachers seek to research problems in their own classrooms so that they can improve students' learning and their own professional performance" (Creswell, 2002, p. 605). I further based the study on the assumption that students' perspectives are essential in improving teaching and learning (Abbott, Wulff, Nyquist, Ropp, & Hess, 1990; Braskamp & Ory, 1994; Marsh, 1984; Seldin & Associates, 1999), particularly in my determining how to

proceed with alignment. As Wulff, Nyquist, and Abbott (1987) emphasized, “Knowing how students interpret and value major instructional dimensions enables an instructor to make informed decisions to enhance the teaching and learning process” (p. 18).

### *Procedures*

I obtained feedback from students at several time intervals. Before introducing each course topic, I had students write about what they knew of that subject. Later, I used formal evaluation, including homework, quizzes, and exams. I gained additional insights from in-class problem sessions as well as from the reflective writing in which students explained at the end of each unit how their thinking about the subject had changed and what helped, or would have helped, them gain a better understanding. I used these data to make ongoing adjustments throughout the course.

All 15 students provided feedback through the university’s student ratings system. However, because I wanted retrospective data that could address slightly different questions than the student ratings included, I also invited students to complete a non-anonymous e-mail questionnaire (see Appendix) and/or to participate in a face-to-face interview after the course ended. Eleven of the 15 students participated in this follow-up several weeks after the conclusion of the course. Five provided e-mail responses; four participated in interviews; and two responded via both e-mail and interviews. The information from these 11 students provided the primary data for this study.

### *Data Analysis*

To analyze the open-ended questions from surveys/interviews, I used basic qualitative methods (Lindlof, 1995; Merriam, 1998; Miles & Huberman, 1984; Strauss & Corbin, 1998), including inductive data analysis, which involved “uncovering embedded information” and making it explicit through the processes of unitizing and categorizing (Lincoln & Guba, 1985). After reading the comments several times, I used the response to each question as the initial unit of analysis but further broke those units into parts when they represented more than one thought or idea. I then clustered and coded the thought units to look for emerging categories and to compare them to the methods used in the course. Although I had in mind my original categories related to use of lectures, student problem-solving, office hours, and written reflections, I remained open to emergent categories and the possibility of adjusting those original categories based on the data. This constant comparative method (Glaser & Strauss, 1967; Merriam, 1998) allowed me to identify not only the key categories but also the properties or subcategories of each major category (Merriam, 1998). Using the properties for each category, I then generated descriptive language to name and explain each of the four major communication categories important in the alignment process.

## **Results: Working Toward Alignment**

To address whether my alignment efforts made a difference, I begin this section by summarizing students' overall perceptions of learning and communication in the course. Then, I explain major categories of communication that emerged from the data analysis.

### *Students' Overall Perceptions of Their Learning*

The mean student rating of the overall degree to which the 11 students' knowledge and understanding of mathematical theory of probability changed during the course was 3.5 on a 4.0 scale, with a range from 3 ("quite a bit") to 4 ("a lot"). Although roughly half the students simply indicated that they had learned, the other half specifically discussed their learning in terms of their ability to address relevant problems. One student wrote:

I knew very little about statistics and thought it was mostly playing with numbers to get a desired outcome. Now, I have a good understanding of the basics of probability and see how it can be used to provide models of real world occurrences.

### *Students' Overall Perceptions of the Communication in the Course*

When asked to provide feedback about how communication in the course could have been improved, six of the 11 interview/survey respondents indicated that they were "not sure" or that the "communication was handled well." In the end-of-term ratings, 10 of the 15 students rated my communication in class in the highest category (excellent), while the other five rated it in the second highest category (good). Additionally, of the 10 students who rated office hours in end-of-the course evaluations, seven rated my communication during office visits as "excellent."

### *Key Communication Behaviors in Alignment*

Throughout the course, I used student input to adjust what I was doing relative to lectures, problem-solving, written reflections, and office hours. When 11 of the students rated the helpfulness of various instructional methods used in the course (range 0 = "not at all" to 4 = "a lot"), the rank order of mean ratings was as follows: problems in class ( $M = 3.55$ ,  $SD = 1.21$ ), homework problems ( $M = 3.36$ ,  $SD = 0.81$ ), lectures ( $M = 2.55$ ,  $SD = 0.93$ ), class discussions ( $M = 2.36$ ,  $SD = 1.12$ ), quizzes ( $M = 2.0$ ,  $SD = 1.18$ ), and written responses ( $M = 1.55$ ,  $SD = 1.13$ ). By having the students explain their ratings and discuss my use of communication, I was able to obtain data that helped me see interrelationships among those methods and identify four key categories of communication related to alignment: encouraging open communication, demonstrating examples interactively, structuring opportunities for application through problem-solving, and engaging students in reflection about their learning.

*Encouraging open communication.* This category emerged from responses to the question about how communication was a factor in the classroom. Three of the students (27%) specifically mentioned the informal environment, with comments such as: “The small class allowed us to be comfortable to ask questions and discuss the problems we were having. The open environment helped me learn what I was having problems with” and “Informal, in-class communication was a big factor in learning course material ... questions could be brought up and discussed in the midst of lecture.”

The informal environment encouraged students to be honest about their difficulties and was particularly helpful in my understanding why efforts to align were sometimes challenging: “I was busy with other classes ... This course was not as important to me as the others” and “The communication did not need to change. I needed to change.”

*Demonstrating examples interactively.* Almost half of the students (45%) mentioned how important it was to have the lectures structured in clear, concise ways. However, what worked best in my role as lecturer was moving away from the traditional lecture style to using examples to engage the students interactively. Many of the students (73%) emphasized that my use of examples enhanced their learning, with comments like: “The examples were good, and slight modifications of them were helpful to illustrate how we need to change our thinking.” and “Watching your examples was most beneficial for me because it gave an idea of how to approach the other problems and explain the different things to look for in each problem.”

Comments from some students (36%) explained explicitly why interaction was important during demonstrations: “Student involvement in class helped me stay awake and focused ... this also made me part of what was going on.” and “Back and forth interaction between the teacher and students was helpful ... Questions from other students helped me see other things and gave me new ideas.”

Despite the positive reactions, two students expressed idiosyncratic perceptions showing that the alignment during the demonstrations was not achieved entirely: “I completely tuned out when students in our class started talking because I assumed they had nothing important to say ...” and “I did not have a problem asking questions, but I think others may have.”

*Structuring opportunities for application through problem-solving.* Of all methods used in the course, students perceived that problem-solving, particularly their own opportunities to practice application, contributed most to their learning. Nearly all students (91%) mentioned the value of being able to apply what they were learning, with such comments as: “I learn best by applying what I’ve been shown to actual problems.” and “The homework problems helped the most because many of them were not just equations given that we had to solve for, but were given as word problems of things that could happen in life.”

Some students (36%), said it was helpful to be able to do the application with

immediate feedback from the instructor or other students: "Having time at the end of class to work a few specific problems individually gave me the opportunity to practice the problems and receive guidance and clarification for any confusion."

One student alluded to successful alignment achieved by my providing problems at an appropriate level: "Working problems ... They made us think but weren't too challenging."

However, alignment was not complete for everyone. Many of the students (64%) wanted practice with even more "real-life problems." Additionally, although some students appreciated the small-group problem-solving, it did not work for everyone: "I actually didn't find the group discussions very useful. Students were generally too shy to get involved." and "Group work is hard since it can be difficult to get people together to get the work done."

*Engaging students in reflection about their learning.* I used two approaches to engage students in reflection about their learning. The first was encouraging the use of office hours. Although not an item rated separately for the surveys/interviews, office hours were identified as significant by 45% of the students. My efforts to align my expectations and the content with individual students during office hours was particularly evident when one student wrote:

The instructor did everything he possibly could to help me, including asking me to come see him in his office so we could talk about my grade ... I can't think of anything else the instructor could have done in order to help me more.

In contrast, written reflections were not perceived as particularly helpful. Although one student rated the written reflections on learning as helping "a lot," most students indicated moderate (46%), little (27%), or no (18%) value in writing responses to in-class questions about learning. After being asked whether the information might be useful for other purposes, however, one student who initially reported that he "did not care" for the reflective questions thought for a moment and then said: "Well, I cannot think of a better way for the instructor to examine student learning."

### **Implications: Reflections on What I Learned**

As I reflect on my evolving efforts to achieve alignment, I can identify several important insights. In this section, I highlight five of those.

First, I have changed my thinking about how I communicate during lectures. I no longer spend time trying to "cover" the content, but rather trying to "uncover" the material. By the end of the semester, students were learning more through interactive demonstrations in which I showed how I approached the problems.

Second, it was helpful to know how much it helped students to solve the problems on their own with guided feedback. As they worked individually and in groups, I heard their questions and saw that they were thinking in ways consistent

with my goals for the course. I also saw a direct link between the importance of opportunities to apply and students' need for more examples. I am still unclear about one issue, however. Although students reported that they liked opportunities for application in problem-solving, they simultaneously were looking to me for a significant amount of demonstration and leadership. Thus, an interesting tension emerged between their own problem-solving activities and a seeming over-dependence on me as lecturer. I intend to examine this tension further when I teach statistics for engineers in the future.

Third, I need to determine how best to use small groups and structure written reflections. Although students indicated that hearing others' perspectives was helpful, they were not as aware of the importance of their contributions to the learning of others—either me or their classmates. In the future, an important part of filling this gap will be for me to couch such activities in what I now know about student learning and to explain in ways that will help students understand, even though they may not see immediate tangible results.

Fourth, across all the settings and activities, I became more aware of how important it is to “listen”—not only to what students are saying, but also to what they are doing. Increasingly, I spent more time listening to their needs and how this course fit into their lives. I also watched them more closely, noting what they wrote down, how they proceeded in applying what they were learning, how they participated, and what they did with the information they received. Through those activities, it was clear that students needed to be supported and encouraged. In particular, listening during office hours provided an opportunity to demonstrate my sincere concern for their learning. Such direct communication was extremely helpful in establishing a trusting relationship. I was surprised by the degree of openness many of them achieved with me. At the same time, careful listening supported my thinking about how to work on alignment. As I listened to them, their openness helped me determine how far they had progressed in their thinking and at what point they were getting so confused (student variable) that I needed to adapt what I was doing (instructor variable) to clarify the material (content variable). For me, focusing on communication reinforced that assessment starts where the student is and with what s/he is doing and *then* moves to determining how I can best adapt my own style and content to help students think statistically.

Fifth, I was better able to assess my overall teaching through the use of the alignment perspective. Examining issues related to interaction of the content, the students, and myself provided a comprehensive guide for thinking about how to achieve the course goals. The question about how students' thinking was changing was particularly helpful for me in judging progress and determining what I might do next. The alignment perspective also reinforced for me that the instructor retains a key role in determining what material is necessary and even what kind of thinking is most important. For example, with a variable like informal classroom atmosphere, which was the antithesis of my own statistical training in, and preference for, formal environments, it was particularly important to be reminded of the instructor's role in alignment. Although using student perceptions provided a way to understand how



students were experiencing the course, it did not mean that I had to abandon my own needs and preferences entirely. Rather, it meant that I had to seek ways to balance the student, instructor, and content variables in the context of what I was hearing from students.

Through this study, I have demonstrated how one faculty member evolved in thinking about how to use communication to enhance teaching and learning in statistics. Although some of these ideas may not be particularly new for communication scholars, they are certainly relevant to experts interested in working with faculty in disciplines other than communication. Here, I have highlighted only a few of the key reflections, but these ideas are enough to demonstrate my interest in further understanding how to use communication to enhance alignment in my statistics courses. The overall impact of this research on my students' learning and on my own development has strengthened my conviction to continue such scholarly study of teaching and learning in my courses.

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## Appendix

### Protocol for E-mail and/or Interview Questions

- I. Rate the degree to which your knowledge and understanding of each of the following areas changed as a result of the course. The scale is:

0 = not at all; 1 = a little; 2 = moderate amount; 3 = quite a bit; 4 = a lot

- (a) \_\_\_\_\_ Probabilities of events and random variables.
- (b) \_\_\_\_\_ Expected value.
- (c) \_\_\_\_\_ Probability distributions for discrete random variables.
- (d) \_\_\_\_\_ Probability distributions for continuous random variables.
- (e) \_\_\_\_\_ Random variables that are jointly distributed.
- (f) \_\_\_\_\_ Mathematical theory of probability, overall.

- II. Briefly explain how your overall thinking and/or knowledge about statistics changed as a result of taking this course.

- III. Rate the extent to which each of the following helped to increase your knowledge and understanding during the course. Give each one a score of 0, 1, 2, 3, or 4 where:

0 = not at all; 1 = a little; 2 = moderate amount; 3 = quite a bit; 4 = a lot

- (a) \_\_\_\_\_ Lectures.
- (b) \_\_\_\_\_ Problems in class.
- (c) \_\_\_\_\_ Homework problems.
- (d) \_\_\_\_\_ Quizzes.
- (e) \_\_\_\_\_ Class discussions.
- (f) \_\_\_\_\_ Written responses to in-class questions.
- (g) \_\_\_\_\_ Other (please explain).

- IV. How did the two most highly rated activities in Part III enhance your understanding of the material?

- V. What else would have helped to improve your knowledge and understanding?

- VI. In what ways did the instructor guide you in understanding the subject? What else could the instructor have done to assist you?

- VII. In what ways was communication (either in- or out-of-class) a factor in helping you to learn the course material?

- VIII. In what ways could communication (either in- or out-of-class) have been handled differently to help you learn the material?

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